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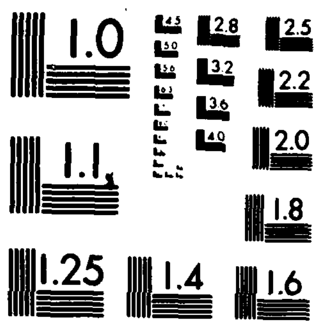

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HIGH PRF HgBr LASER LIFE TESTING

Final Report covering
4/1/82 to 4/30/83

by

C. S. Liu & I. Liberman

Contract No. N00014-82-C-0347

Office of Naval Research

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INTRODUCTION

This report summarizes research work performed at the Westinghouse R&D Center under Contract No. N0014-82-C-0347 for the period between April 1, 1982 and April 30, 1983. The major effort was to perform experimental life tests of an UV pre-ionized HgBr discharge laser, and verify noble metal (gold) electrodes for long life operation in the HgBr laser. → cont'd pg 9

During past years, we conducted experimental lifetime studies of small scale ($\sim 1\ cm^3$) HgBr laser discharges[1] in which tests were made under similar gas compositions, power loading and repetition rate of an actual HgBr laser. During the entire life test, the discharge fluorescence was monitored and compared with the HgBr laser side light fluorescence. The HgBr fluoroescence and laser output showed little or no change throughout the entire life test even though an increase in black deposit on the wall became noticeable toward the end of the test. The life test of the HgBr laser discharge was terminated after 10^8 shots and chemical analyses indicated that no gold or platinum bromide was formed and platinum were sputtered from the preionizer sparks. There was no discoloration of the gold plating on the electrode assembly. The $HgBr_2$ still retained its original form and no $HgBr_2$ loss was observed.

In this report, we will describe the construction of a long life high prf HgBr laser made of gold plated nickel and present life test data which confirm the results of the previous discharge tests. Finally, we will recommend the future design of a practical 10^{10} shots HgBr laser.

EXPERIMENTAL RESULTS & DISCUSSION

A high repetition rate self-sustained glow discharge HgBr laser using Ne/N_2 mixtures as a buffer gas was fabricated almost entirely from glass, gold plated nickel, gold sheet and platinum. The discharge gases flowed through two parallel electrodes with the aid of a magnetic coupled squirrel cage blower (see Figure 1). The blower was made of nickel and then gold plated for chemical protection. The blower bearings used were made of polyimide which have been life tested under discharge conditions at 150°C over hundreds hours with very little wear observed. The electrodes were made of profiled nickel which were gold plated and then capped with 5 mil gold foil. The UV preionization was generated from an array of sparks formed by platinum wires. The active laser gain medium was about 0.3 cm wide, 1 cm gap and 12 cm long. The tests were conducted at a pulse repetition rate of 50 Hz. The input energy was stored in four 2,700 pf ceramic capacitors charged to 10 kV through a LC network. The energy was discharged through a grounded grid EG&G 3202 thyratron. During the entire life test, a vacuum photo-diode was used to monitor the laser output. The laser discharge side light fluorescence was also periodically measured with an EG&G OMA 2.

From previous HgBr laser discharge tests we observed high loss rates of gold and platinum from the main electrodes and UV preionizers which made us aware of potential problems resulting from metallic coating of dielectrics. In this new laser design, we inserted two baffles to confine the gas circulation which significantly reduced the possibility of the coatings of optics. The combination of chemical inertness and careful design resulted in the laser output remaining constant during the entire life test.

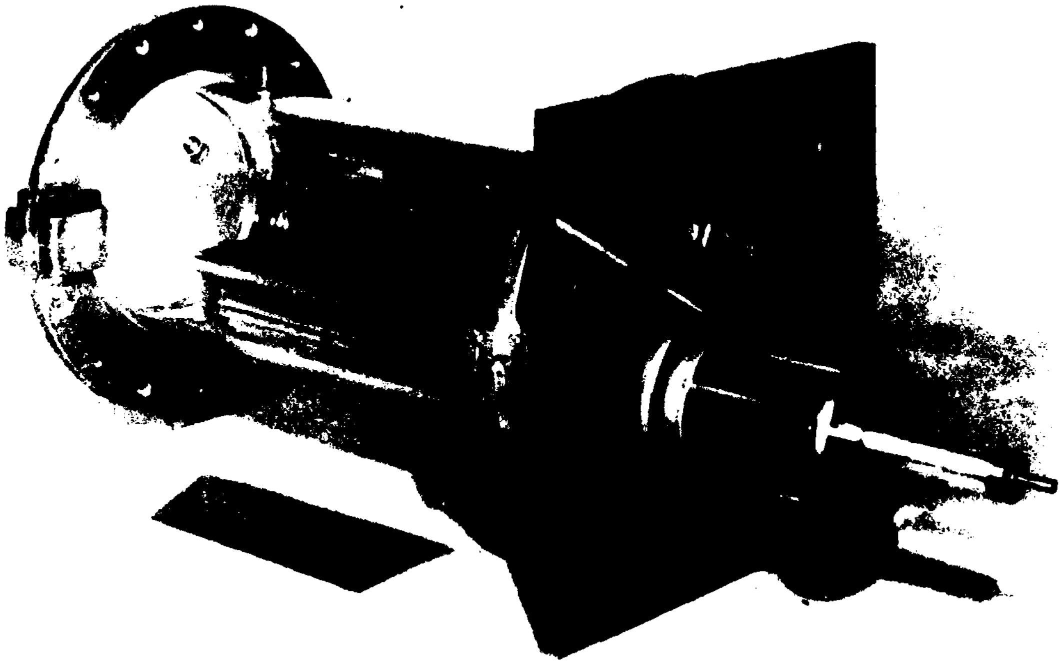

Figure 1 High PRF HgBr laser designed for lifetesting.

Since the active length of this laser is only 12 cm, the specific laser energy output and efficiency were not as good as larger lasers. For a 3.5 cc active volume we obtained only .38 mJ/pulse at 50 pps with about 0.1% efficiency. The output stability from pulse to pulse varied nearly 15% while the long term stability changed less than 5% until the test was terminated at 5.6×10^6 shots. Figure 2 shows typical waveforms of the laser output (lower trace) and the discharge voltage (upper trace). The voltage ringing was mainly caused by the mismatch of the internal impedance of the pulser to that of the discharge. The laser started lasing about 10 nsec after the discharge voltage collapsed and the laser pulse width was about 70 nsec FWHM. No effort were made to improve the impedance match or to optimize the laser output because the main objective of this contract was to life test the laser. Figure 3 shows the laser output as a function of running time. From zero to 5.6×10^6 shots, we have not noticed any sign of laser deterioration and the laser output was kept constant at 380 μJ per pulse until a blower problem developed. Actually, the blower had a very minor mechanical problem and it should not have had occurred. Set screws which fasten the blower to the shaft were shaken loose by the vibration. In order to fix the blower problem, our HgBr laser life test was interrupted at $\sim 5.6 \times 10^6$ shots. A minor material loss from preionizers was observed but no coating on the optics was detected. Sputtering loss of gold from the main electrodes were unmeasurable except for a slight loss of surface shine of the gold foil (it should be expected!!). The appearance of the gold-plated electrode structure showed no sign of discoloration and contamination. A search for Hg_2Br_2 crystals by a UV fluorescence method indicated that there was no net loss of bromine. The blower sleeve bearings showed very little wear after 5×10^6 shots except for the set screws which were shaken loose. This problem should be easily corrected by using self-lock type screws. The two gold-plated end plates turned slightly black due to some biomine attack. It is believed that there were a few micro—pinholes in the gold plating. These pinholes could have been there during the original plating or they could be caused by

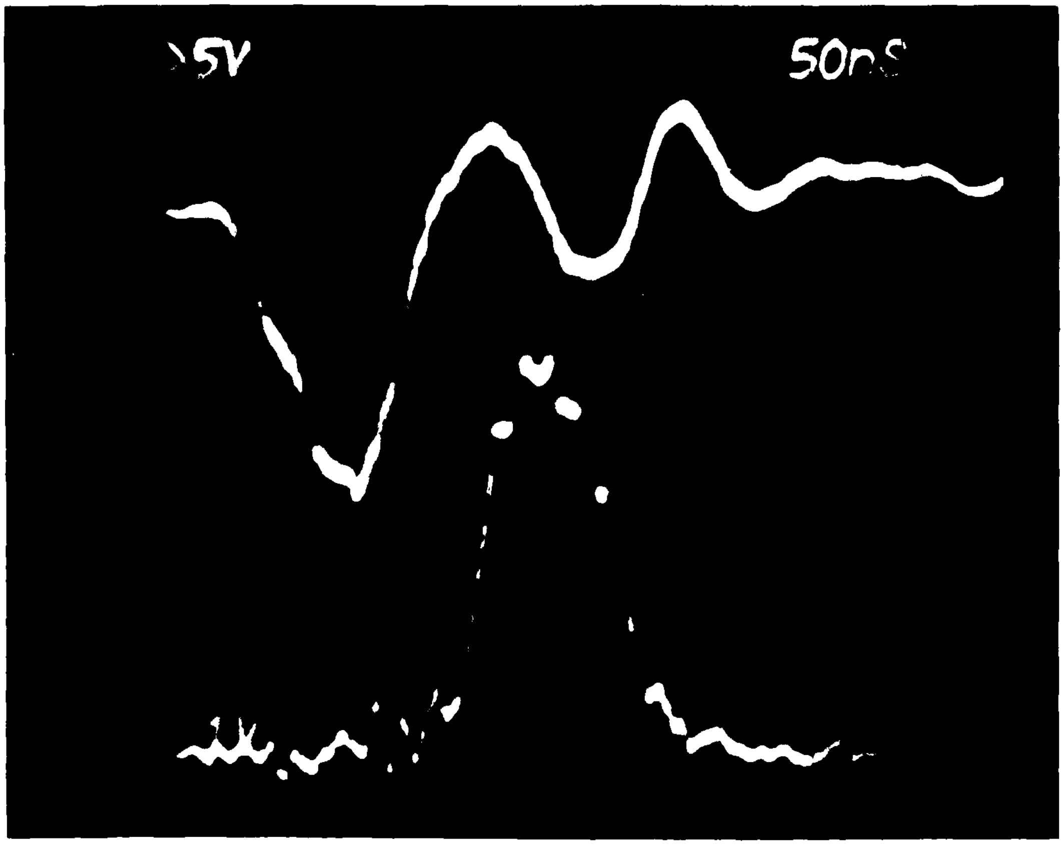

Figure 2 Typical waveforms of the discharge voltage (upper trace) and laser output (lower trace).

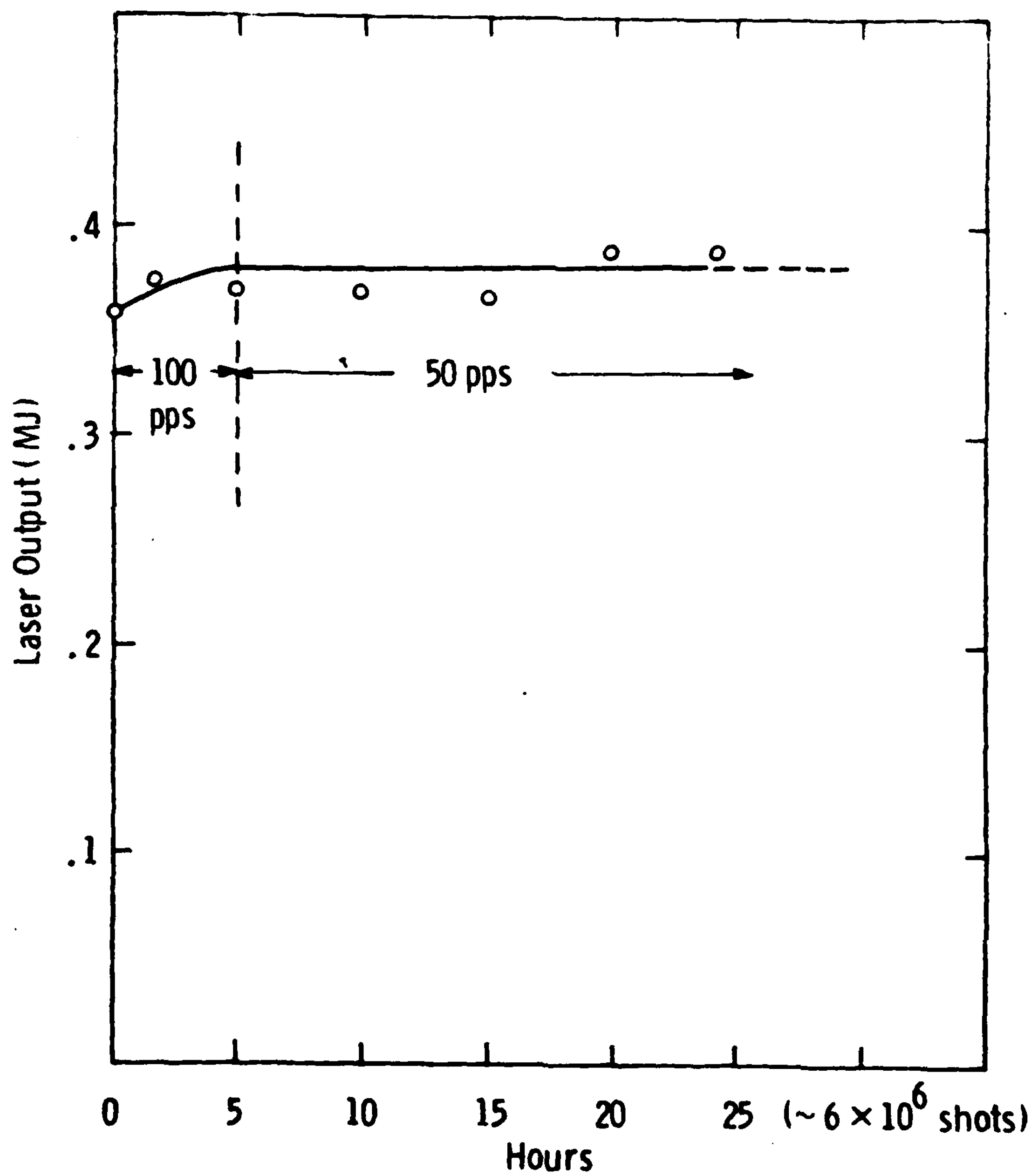

Figure 3 HgBr laser output vs. operating time

Hg-Au amalgamation. However, the latter assumption is not probable because if the amalgamation occurred it should start at the electrode assembly since it was closest to the $HgBr_2$ discharge and had the highest density of free mercury. As we have mentioned previously, there was no sign of degradation of the electrode assembly. Hence, in order to prevent chemical reaction, micro-pinholes in the gold plating should be avoided.

Most metals are prone to bromine attack and pinhole free gold plating may be very difficult to achieve for a large system. An ideal solution to a long lived (over 10^{10} shots) HgBr laser is to provide a closed cycle chemical reconstitution mechanism to rejuvenate the $HgBr_2$. The schematic diagram of such a system is shown in Figure 4. We are initiating an experimental study on a high repetition rate HgBr laser made of noble metal electrode and regular stainless steel supporting structures with a $HgBr_2$ reconstitution system. From this test we may be able to provide an alternate superior design and demonstration of a long-lived, practical HgBr laser.

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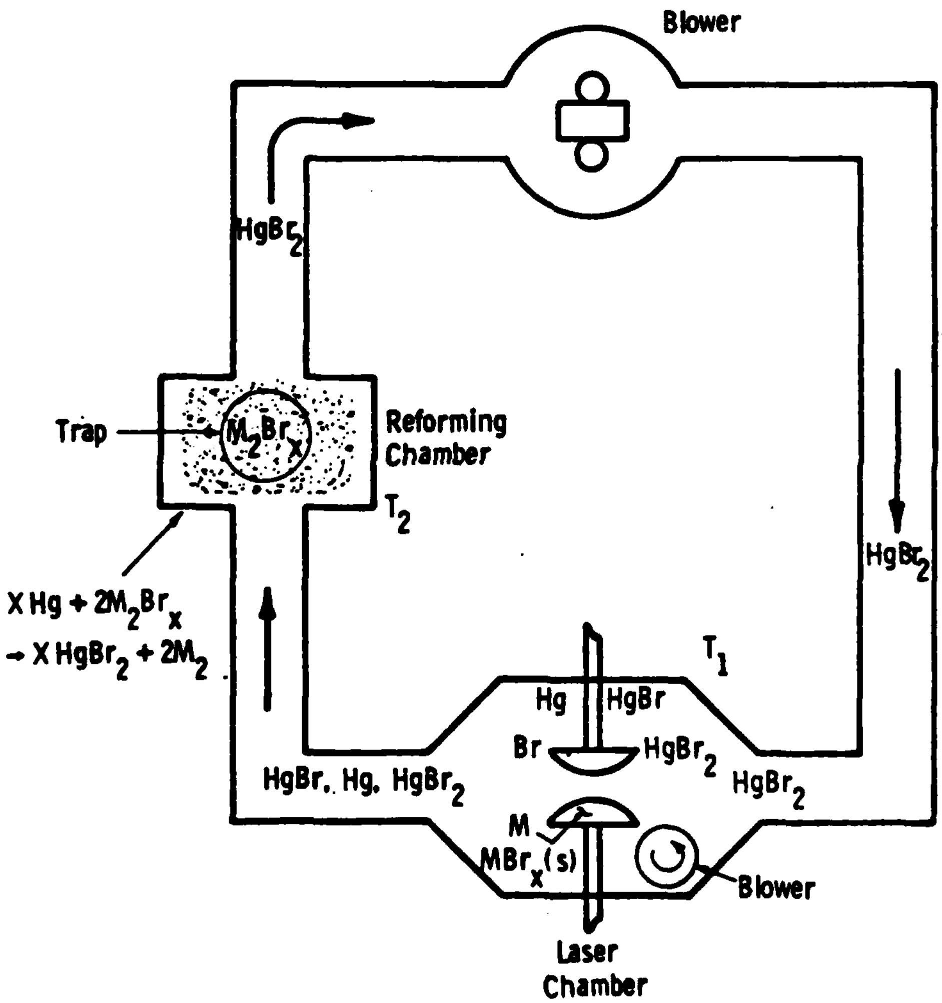

Figure 4 Mercuric halide recovery system.

CONCLUSIONS & SUMMARY

Based on the test results of our gold-plated nickel HgBr laser there was no sign of laser deterioration at over 5×10^6 shots until unexpected and unnecessary blower problems forced us to interrupt the test. By operating the laser near threshold conditions gave a particularly sensitive test to chemical degradation. The previous laser discharge study and the true laser test indicated that the pinhole-free gold plated nickel was chemically inert to the HgBr. Both tests made us firmly believe that the properly designed HgBr laser can easily last 10^8 shots. For a larger laser system with further improved operating life, we suggest the addition of a $HgBr_2$ reconstitution system.

REFERENCES

1. C. S. Liu and I. Liberman, "Mercury Bromide Laser Discharge Life Studies," Final Report (May 1, 1981 to January 31, 1982), ONR Contract No. N00012-81-C-0485.

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